

We claim:

1. In x-ray imaging systems for digital radiography, an apparatus for the automatic detection of the start of irradiation comprising:

5 1.1. A x-ray source, not connected with the imaging system, controlling the irradiation upon command from the operator.

1.2. A x-ray imager, aligned with the x-ray source, and electrically coupled to a suitable control unit.

1.3. A control unit, controlling the operating modes of the x-ray imager and providing the following functions:

10 (a) IBM (Initial Blemishes Mapping).

Functional unit performing the initial read out of the whole imager pixel matrix, and creating a map of the pixels or super-pixels showing blemish defect.

(b) SRC (Standby Readout Cycle).

15 Functional unit performing a cyclic read out of the imager matrix during the standby phase. The read out has the consequential effects of removing at each cycle the dark current accumulated in all pixels of the matrix, and providing an output signal related to pixels, or super-pixels, for the later processing by the TSU and XDU functions.

20 (c) XDU (X-ray Detection Unit).

Functional unit processing the output generated by the SRC function, comparing it with a first threshold 1 (TH1), to identify the pixels, or super-pixels, providing x-ray stimulated output signal, counting the number of such pixels, and comparing the count with a second threshold (TH2). In case that
25 the count exceeds the second Threshold Reference (TH2), the start of

irradiation is identified and a control signal is generated to trigger the transition of the imager to integration mode.

(d) TSU (Temperature Simulation Unit).

Functional unit performing a simulation of the imager temperature and accordingly a correction of the first Threshold Reference (TH1) value, to account for variations of the dark current related pixel (or super-pixel) signal in consequence of variations of the device temperature.

and a method for the automatic detection of the start of the irradiation, including the steps of:

- 10 A) Performing, after switch on of the apparatus, an initial readout of the imager matrix by the IBM function, to generate a map of the pixels (or super-pixels) showing blemish defect.
- B) Performing, during the standby phase, a cyclic read out of the imager matrix using the SRC functional unit. At each cycle (i) the functional unit will generate the output
15 $O(i,j)$, where (j) is the index of the element. The read out may be executed either by pixel or by super-pixel, eventually sub-dividing the imager area in sections. The read out will have the consequential effect of removing at each cycle the dark current accumulated in all pixels of the matrix.
- C) Processing the output of the SRC function by the TSU function, in order to provide a
20 simulated value of the device temperature and a correction of the first Threshold Reference (TH1).

In the general arrangement the simulation $T(i)$ of the imager temperature at the cycle (i) will be a function $f[O(i,j)]$ of the output $O(i,j)$ generated by the SRC functional unit at the cycle (i), while the Threshold Reference 1
25 Corrected $TH1c(i)$ at the cycle (i) will be a function $f[TH1c(i-1), T(i)]$ of the

Threshold Reference 1 Corrected $TH1c(i-1)$ at the cycle $(i-1)$, and of the simulated temperature $T(i)$ at the cycle (i) .

D) Processing the output of the SRC function by the XDU function, to detect the start of irradiation.

5 In the preferred arrangement the output $O(i,j)$ produced by the SRC functional unit will be compared with a first threshold 1 ($TH1$), to identify the pixels, or super-pixels, providing x-ray stimulated output signal. The number of such pixels, or super-pixels, will then be counted, and will be compared with a second threshold ($TH2$). In case that the count will exceed the second Threshold Reference ($TH2$), the
10 start of irradiation will be identified and a control signal will be generated to trigger the transition of the imager to integration mode.

2. The apparatus and method as set forth in claim 1 wherein the Imager matrix initial readout is performed pixel by pixel, and the IBM function analyses the output signal
15 from each imager matrix pixel and records individually the pixels having signal in excess of a predefined threshold reference quantity.

3. The apparatus and method as set forth in claim 1 wherein the imager matrix initial readout is performed having divided the matrix in sections and within each section
20 having binned the pixels together (so creating a super-pixel), to reproduce the same readout policy adopted during the standby readout by the SRC function. The output signal from each super-pixel is analysed and, for each imager section, the super-pixels having signal in excess of a predefined threshold reference quantity are individually recorded.

4. The apparatus and method as set forth in claim 1 wherein the imager matrix read out performed by the SRC function during standby period is done having divided the matrix in sections and within each section having binned the pixels together (so creating a super-pixel), so generating an output signal referred to each super-pixel.
5. The apparatus and method as set forth in claim 1 wherein the imager matrix read out performed by the SRC function during standby period is done having divided the matrix in sections and within each section having binned the pixels together (so creating a super-pixel), using a preferred variant where all the lines of the section are first clocked into the readout register and then the readout register is clocked out, so generating an output signal referred to each super-pixel consisting of a column of the section. The variant will be particularly advantageous in applications where the reduction of the power consumption is required, by minimisation of the higher frequency readout register clocks, as applicable, but not limited to, CCD imagers with control electronics self powered from the USB port of a Personal Computer.
6. The apparatus and method as set forth in claim 1 wherein the simulation $T(i)$ of the imager temperature at the cycle (i) performed by the TSU functional unit is obtained by processing the output $O(i,j)$ generated by the SRC function at the cycle (i) and calculating the function $f[O(i,j)]$ as the average over a consistent number of pixels, or super-pixels, which were not identified as blemishing by the IBM functional unit.

7. The apparatus and method as set forth in claim 1 wherein the calculation of the Threshold Reference 1 Corrected (TH1c) at the cycle (i) performed by the TSU functional unit is obtained by adding to the Threshold Reference 1 Corrected (TH1c) at the cycle (i-1) a term derived by the simulated temperature T(i) multiplied by a constant scaling factor (k), according to the relation

$$TH1c(i) = (1-k) * TH1c(i-1) + k * T(i).$$

8. The apparatus and method as set forth in claim 1 wherein the XDU functional unit replaces at each cycle (i) the first Threshold Reference (TH1) by the Threshold Reference 1 corrected TH1c(i), as calculated by the TSU functional unit at the cycle (i).

9. The apparatus and method as set forth in claim 1 wherein the XDU functional unit processes the output O(i,j) generated by the SRC function at the cycle (i) and rejects output values which are exceeding the TH1 level (or alternatively the TH1c level) but which are also corresponding to pixels or super-pixels previously identified by the IBM function as blemishing.

10. The apparatus and method as set forth in claim 1 wherein the XDU functional unit processes the output O(i,j) generated by the SRC function at the cycle (i) and identifies the start of irradiation by the simple detection of the first output signal exceeding the first threshold TH1 level (or alternatively the TH1c level).

11. The apparatus and method as set forth in claim 1 wherein a derivative approach is used by the XDU functional unit to identify the start of irradiation, by processing the output $O(i,j)$ generated by the SRC function at the cycle (i) and comparing with a single Threshold Reference (TH1 or alternatively TH1c) the variation of the output signal between adjacent pixels or super-pixels, and detecting the first instance where the variation exceeds the threshold.

12. The apparatus and method as set forth in claim 1 wherein an integrative approach is used by the XDU functional unit to identify the start of irradiation, by processing the output $O(i,j)$ generated by the SRC function at the cycle (i), integrating the output signal, comparing the integrated value with a single Threshold Reference (THR), and detecting the first instance where the integrated value exceeds the THR.